[10191/2188]

OPERATING DEVICE

FIELD OF INVENTION

The present invention relates to an operating device.

BACKGROUND INFORMATION

Conventional operating devices, e.g., in the form of a so-called computer mouse or a track ball having a spherical operating element are available for personal computers. These are typically used for two-dimensional inputs, e.g., for controlling the position of a pointer within a two-dimensional menu shown on the computer screen. In this context, the spherical operating element in such a conventional operating device is typically supported such that a translatory movement of the sphere within the surrounding housing is largely prevented.

An operating device having a spherical operating element in the form of a lockable track ball is described in PCT Patent Application No. WO-A 98/54670. The spherical operating element described therein has trough-like recesses on its surfaces with which detent elements engage. For the operator, this renders possible improved haptic feedback regarding the extent of the adjustment of the parameter adjusted using the spherical operating element. Therefore, it may no longer be necessary to visually monitor the parameter to be adjusted. As such, the described device is particularly suitable for use in such devices where it is not possible or it is difficult to visually monitor the parameter to be adjusted.

SUMMARY

In accordance with an example embodiment of the present invention, an operating device is provided that has the advantage that the user receives a good haptic response during operation, in that the torque necessary for moving the spherical operating element is changeable, e.g., as a function

of the parameter to be adjusted. Thus, the user receives via the instantaneous torque needed to move the spherical operating element haptically conveyed information, e.g., regarding the extent of the parameter to currently be adjusted or also regarding the fact that, within a selection list (menu), for example, the user is approaching an end of the menu. It is, therefore, not necessary to visually monitor the parameter to be adjusted or the current position within a menu. The example operating device is, thus, suitable in a special manner for operating devices under such circumstances in which it is not possible or is at least difficult or undesirable to visually monitor the adjustment.

The example operating device is, consequently, particularly suitable, e.g., for use in connection with devices operated in motor vehicles, such as an audio system or a navigational device, since the driver is able to give his/her full visual attention to the traffic while simultaneously safely operating the devices.

A particularly simple example embodiment of the operating device of the present invention provides an arrangement for influencing the torque needed to rotate the spherical operating element in the form of at least one plunger that is pressed against the spherical operating element with a predefinable force.

A particularly advantageous example embodiment of the present invention provides that for influencing the torque needed to rotate the spherical operating element, actuators are provided that, in response to a movement of the spherical operating element, apply a predefinable torque opposite the movement of the spherical operating element.

In addition to influencing in a parameter-dependent or context-dependent manner the torque needed to move the spherical operating element, the actuators make it possible to

achieve stop or step effects such that, in response to the spherical operating element being displaced from a neutral position, e.g., a certain menu point within a menu, the operating element automatically jumps to the next stable position, e.g., to the next menu point within the menu. This is possible, for example, in that, in response to the spherical operating element being moved from the neutral position, the actuator generates a torque to further move the spherical operating element to the next stable position.

A simple advantageous example embodiment of an actuator for influencing the torque to rotate the operating element with which the described stop or step effect is also representable includes an electromotor having a corresponding activation, a roll connected to the spherical operating element in a frictionally engaged manner being situated on the electromotor's shaft.

Passive stop effects may also be achieved using the indicated actuators, so that when the spherical operating element is in a position of rest, a greater torque is needed to move it than when in an intermediate position.

Active stop or step effects may also be achieved, so that in response to the spherical operating element being moved out of a neutral position or a pointer controlled by the operating element or a marking being moved from a point within a menu, a torque opposite the rotary motion, yet cooperative, is first generated after a certain position of the operating element or of the pointer is passed in the list.

A further advantage of an example embodiment of the present invention is that by increasing the torque needed to rotate the spherical operating element, a rotation of the spherical operating element is able to be blocked about at least one axis of rotation. As such, the user is able to receive information, e.g., as to whether he/she is currently in a one

or two dimensional menu.

Another advantage of an example embodiment of the present invention is that by suitably controlling the characteristic of the torque needed to rotate the spherical operating element, the haptic of the operating element is able to be adapted to the particular context. Thus, the haptic of the operating element is able to be adapted in the one case to that of a conventional potentiometer, in another case to that of an incremental indicator, and in a final case, e.g., to a stop switch having a plurality of stop positions.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a block diagram of an operating device in accordance with an example embodiment of the present invention.

Figure 2 shows a Cartesian coordinate system that is the basis of the following representations and shows three translatory and rotational degrees of freedom.

Figure 3 shows a section of an operating device according to a first example embodiment of the present invention.

Figure 4 shows a top view of the operating device according to the first example embodiment.

Figure 5 shows a section of an operating device according to a second example embodiment of the present invention.

Figure 6 shows a top view of the operating device according to the second example embodiment of the present invention.

Figure 7 shows an alternative example embodiment of the spherical operating element in connection with a third example embodiment of the present invention.

Figure 8A shows an example one-dimensional menu as part of a two-dimensional menu having a characteristic of the torque needed to move spherical operating element 10 as a function of the position of a pointer or a marking within the menu.

Figure 8B shows two further example one- dimensional menus as part of the same two-dimensional menu having corresponding torque characteristics.

DETAILED DESCRIPTION

Figure 1 shows a block diagram of an example embodiment of the present invention. As shown in Figure 1, an operating device includes an exactly or largely spherical operating element 10, a detection circuit 150 for determining a rotation of spherical operating element 10 as well as for determining the rotational direction and a covered angle of rotation. The operating device also includes an arrangement 60, 61 for influencing the torque to rotate spherical operating element 10, power electronics 170 for controlling an arrangement 160 for influencing the torque as a function of the output signals of a control, a memory 180 for torque characteristics, and a control 190 for processing the output signals of detection circuit 150, for assigning operating states of device 195 to be controlled to torque characteristics stored in memory 180, and for controlling means 160 for influencing the torque via power electronics 170.

Cartesian coordinate system 100, which provides the basis for the following embodiments and has three translatory degrees of freedom 101, 102, 103 corresponding to the three axes of the coordinate system conventionally designated as x, y, and z and three rotational degrees of freedom 105, 106, 107 about the appertaining axes of the coordinate system, corresponding to designations ϕx, ϕy, ϕz used in the following, is represented in Figure 2 to facilitate understanding.

Figure 3 shows a section of an operating device 1 according to a first example embodiment of the present invention, as it is used, e.g., as an operating device of an car radio, e.g., for selecting a radio program from a list of radio programs receivable at the vehicle's location.

Operating device 1 includes a spherical operating element 10, which is supported in a housing 50 such that a translatory movement of spherical operating element 10 is not possible. In the present exemplary embodiment, sphere 10 is supported by a first support 15 situated under sphere 10 and by edge 52 of a circular opening 55 in housing 50 shown in Figure 4, sphere 10 partially protruding through opening 55. In this context, sphere 10 is inserted with minimal play between first support 15 and edge 52 of housing opening 55, so that it is possible to rotate sphere 10 about its three rotational degrees of freedom shown in Figure 2, axes of rotation ϕx, ϕy and ϕz.

In another example embodiment of the present invention, sphere 10 is supported in such a manner that a support is disposed at each corner of an imaginary tetrahedron filling in the sphere, so that the supports rest exactly on the sphere surface. In this case, for example, three of the total of four supports are disposed around round opening 55 of the housing, the fourth support being situated at the location of first support 15.

The supports can be configured as ball bearings or, as in the present case, as sliding bearings.

It is also possible to support sphere 10 using a single sliding bearing, namely in the form of a spherical interior space of housing 50 adjusted to the diameter of sphere 10.

The described example embodiments have in common preferably circular housing opening 55, which enables the user to access spherical operating element 10 to influence its angular

position. In this context, the user is able to operate spherical operating element 10 via opening 55 in a manner similar to operating computer trackballs. However, it is also possible to guide operating device 1 of the present invention in a translatory manner over a flat surface in the manner of a conventional computer mouse, having housing opening 55 pointing downward and operating element 10 projecting through the opening, and to generate a rotary movement of spherical operating element 10 by friction locking sphere 10 with the flat surface.

An alternate example embodiment of spherical operating element 10 shown in Figure 7 is designed such that it is made up of two partial elements 11 and 12, of which in each case one is disposed on one of two axes 13 and 14, which run, for example, perpendicularly to one another. In this example embodiment, a first partial element 11 of spherical operating element 10 may be designed as a solid sphere attached to an axis 13, which is horizontal, i.e., runs parallel to the x axis of the coordinate system, while second partial element 12 is designed as a hemisphere situated on a vertically running second axis 14 that partially surrounds solid sphere 13, namely at its bottom region. Both axes 13, 14 may be slidably supported and oriented perpendicularly to the respective walls of housing 50. However, it is not essential to arrange both axes 13 and 14 perpendicularly to one another.

In this example embodiment of spherical operating element 10, the first partial element 11 has vertically running ribbing, and second partial element 12 has horizontally running ribbing, thereby improving the gripping capacity of the operating element especially in the case of higher torques being needed to rotate the operating element.

In a conventional manner, the detection circuit is produced in the form of an optical scan of the surface of the spherical operating element and a corresponding evaluation circuit or

evaluation software. For this purpose, spherical operating element 10, which is irradiated by at least one light source, has a surface penetrated by dark points, the dark points absorbing the light emitted by the at least one light source, while the remaining areas of the sphere's surface reflect the light. Thus, in response to the sphere being rotated, one or more light-sensitive sensors detects light pulses from which information regarding the direction of rotation and, by counting the pulses, also regarding the angle covered by the spherical operating element is derived. In addition, reference is made, for example, to a trackball, e.g., to the conventional model "TrackMan Marble FX" by the company Logitech.

To influence the torque needed to rotate sphere 10, an arrangement is provided in the form of a plunger 30 in the case of the first example embodiment according to Figures 3 and 4, the plunger being pressed horizontally, i.e., from the side in the x direction, with a predefinable force against sphere 10. On contact surface 32 facing sphere 10, plunger 30 has a coating preferably having a high friction coefficient, e.g., a rubber coating. If a force directed in the direction of sphere 10 is exerted on the plunger, a mechanical friction and, thus, a braking effect for the sphere with respect to its rotational axes y and z consequently sets in between sphere 10 and plunger 30. This means that an increased torque is needed to rotate sphere 10 about the y and z axis, i.e., in the ϕy and ϕz direction.

Increasing the pressing force acting on plunger 30 above a certain threshold value may result in an increase in the torque needed to rotate sphere 10 about rotational axes y and z, thereby virtually blocking rotation axes y and z and, thus, rotational directions ϕy and ϕz. In the present example embodiment, a second support 20, against which sphere 10 is pressed in response to a pressing force acting on plunger 30, is situated on the side of sphere 10 opposite the contact side

of the plunger. Second support 20, which is situated on the opposite housing wall in the present case, ensures that a pressing force acting on plunger 30 only influences rotational axes y and z of the sphere and not the torque needed to rotate sphere 10 about its rotational axis x. Sphere 10, consequently, remains freely rotatable about its rotational axis x in the case of a pressing force being applied to plunger 30.

Moreover, as shown in the top view of operating device 1 in Figure 4, the present example embodiment includes, analogously to first plunger 30 and corresponding counter-support 20, a second plunger 35, which is perpendicular to first plunger 30 and is situated along the z axis of the underlying coordinate system, and a third support 25, which is situated on the opposite housing wall as the counter-support for sphere 10.

In response to a pressing force being applied to only plunger 35 along the z axis of the underlying coordinate system according to Figure 2 in the direction of sphere 10, the mechanical friction acting between second plunger 35 and sphere 10 results in an increase in the torque needed to rotate the sphere about rotational axes x and z. In this case, the torque for rotating sphere 10 about the y axis, i.e., in the ϕy direction, is not affected.

In the case of the support for supporting sphere 10 being arranged in a tetrahedral manner, the above-described counter-support, i.e., second support 20 and third support 25, may be dispensed with. However, the indicated counter-supports make it possible to better clamp sphere 10 in the case of acting pressing force of one of plungers 30 or 35.

Figure 5 shows a section of an operating device 1 according to a second example embodiment of the present invention, as used, e.g., as an operating device of a car radio.

In a second example embodiment of the present invention, the arrangement for influencing the torque needed to move spherical operating element 10 is designed as actuators, i.e., control elements, instead of plungers 30, 35, which are able be pressed against sphere 10. In this context, the actuator, which replaces second plunger 35 in the present example embodiment, is not shown in Figure 5 for the sake of clarity.

In the second example embodiment of the present invention shown in Figure 5, the indicated actuators are designed in the form of electromotors 60 and 65. Situated on the shafts of motors 60 and 65 are rolls 61 and 66, whose rotational direction runs parallel to the y axis of the underlying coordinate system, and which are frictionally engaged with spherical operating element 10.

Figure 6 shows a top view of the second exemplary embodiment of the present invention shown in Figure 5. In this instance, the actuators are again represented in the form of electromotors 60 and 65, on whose shafts rolls 61 and 66, which are frictionally engaged with spherical operating element 10, are situated, the rolls being used to transmit the torque generated by electromotors 60 and 65 by suitable control to spherical operating element 10. In this context, electromotors 60 and 65 and, thus, rolls 61 and 66 are situated such that the shaft of motor 60 is aligned parallel to the y axis and that of motor 65 is aligned along the x axis of underlying coordinate system 100, so that roll 61, which is joined to first motor 60, transfers a torque in ϕy direction, and second roll 65, which is joined to second motor 65, transfers a torque in the ϕx direction to spherical operating element 10.

The actuators, in the present case the electromotors, are able to influence the torque needed to rotate spherical operating element 10 in that, given a rotation of the spherical operating element about one rotational axis y or x, the

appropriate actuator generates in each case a torque that counters or follows the rotary motion.

In the case of the present direct voltage electromotors, the torque opposing the rotary motion is achieved by applying a direct voltage that would cause the motor shaft to rotate in the rotational direction opposite the rotational direction impressed by the user.

A third example embodiment of the present invention is shown in Figure 7 in conjunction with the alternative specific embodiment of spherical operating element 10.

According to one embodiment of the third example embodiment an arrangement, via which a braking torque is able to be transferred to partial elements 11, 12, respectively, of the spherical operating element in a mechanical or electrical or electromagnetic manner, is situated on axes 13 and 14, on which partial elements 11, 12 of spherical operating element 10 are arranged, outside of the region accessible to the user.

In another embodiment of the third example embodiment represented in Figure 7, both axes 13 and 14, on which partial elements 11 and 12 of spherical operating element 10 are situated, are connected to actuators. Suitably activating the actuators causes predefinable torques to be transferred to partial elements 11 and 12, respectively, of spherical operating element 10. In the exemplary embodiment shown in Figure 7, toothed wheels 62, 67 are attached to both axes 13 and 14, on which partial elements 11 and 12 of spherical operating element 10 are situated, outside of the region that is accessible to the user, toothed wheels 62, 67 being connected to electromotors 60 and 65, on whose shafts additional toothed wheels 63 and 68 are then attached, which mate with toothed wheels 62 and 67 situated on axes 13 and 14, so that predefinable torques are able to be transferred to partial elements 11 and 12, respectively, of spherical

operating element 10 by suitably controlling electromotors 60, 65.

The indicated power electronics has the task of activating the means for influencing the torque needed to rotate the spherical operating element, i.e., the plungers or actuators according to the described exemplary embodiment, as a function of the control signals emitted by the control and, thus, to influence the torque needed to rotate the spherical operating element. For this purpose, the power electronics essentially includes power amplifiers for converting a control signal, for example, to a voltage to be applied to a motor as an actuator and for preparing the electrical current needed for generating the torque predefined by the control signal.

Stored in the indicated memory are torque characteristics that are assigned to different operating states of the device that is operated using the operating device of the present invention. For example, a first torque characteristic for adjusting the volume of a car radio as a device to be controlled is stored in the memory, the torque characteristic differing in that, starting with low torque values, the torque needed to rotate the operating element increases with increasing volume. Also stored in the memory is, for example, a second torque characteristic for adjusting the sound of an audio signal to be reproduced, where, starting from a low value for a neutral sound adjustment, the torque needed to rotate the operating element increases in response to an adjustment to a reproduction with more bass or more treble. Also stored in the memory is, for example, a torque characteristic for scrolling in a horizontally situated header of a two dimensional menu in which the parameters or functions to be selected are listed, the torque characteristic causing the operating element or the pointer controlled by it or the marking to stop on the different parameters and/or functions selected when scrolling in the header.

Finally, the control is provided for adjusting the torque needed to rotate the spherical operating element to a certain context, i.e. for defining a constant torque for adjusting parameters. For this purpose, the control reads out a torque characteristic from the memory as a function of the parameter to be adjusted or as a function of a function to be adjusted and controls the value of the torque to be applied to the spherical operating element by the user as a function of the instantaneous position of a pointer or a marking in the respective menu.

In a first specific embodiment, a stop function for the spherical operating element is achieved in the case of a rotary motion of spherical operating element 10, e.g. in the case of scrolling from a first to a second point within a menu, so that, the points of the menu are locked on with regard to the torque needed to rotate the operating element. For this purpose, the torque of spherical operating element 10 is influenced as a function of the position of a pointer or of a marking within a menu such that a high torque is needed to move the sphere out of a position corresponding to a point of the menu, while a lower torque is sufficient the pointer is positioned between two points. Thus, the user must overcome a high torque when displacing sphere 10 to shift the pointer of the marking within the menu from a point. If the torque decreases after leaving the point, the user, who cannot immediately adjust to this decrease in torque, will involuntarily continue move the operating element in the direction of the original deflection until a new point is reached at which a high torque would again be necessary to move sphere 10 further. The described torque characteristic results in a stop effect for the sphere at the assigned points of the menu.

In another specific embodiment of the second exemplary embodiment, an active jump function of the sphere is achieved such that, after moving the sphere from one position

corresponding to one point in the menu, a torque counteracting the motion is initially generated, and it increases until the next point in the menu is closer to the momentary position of the pointer controlled by the sphere in the menu than the previously set point. As soon as the pointer approaches the selected point in the menu, the torque acting on the spherical operating element is controlled such that the sphere continues to rotate even without the influence of the user, i.e., it jumps until the pointer reaches the next point in the menu.

In Figure 8, a car radio having different adjustable parameters and functions, e.g., a list of radio programs receivable at the receiving location, the reproduction volume, a sound adjustment, and other parameters is to be operated using the operating device according to the present invention. A menu, designed as a conventional two dimensional menu, is displayed on a display device of the device to be operated is designed.

The selectable parameters and/or functions, namely a program selection 201, a volume adjustment 202, and a sound adjustment in the form of a so-called sound balance 203, as well as additional function 204, e.g., a source switching element for selecting an audio signal source, such as a built-in cassette device, a connected CD player, and a radio receiver are represented next to one another in the form of a header of the two dimensional menu 200. The different indicated parameters and functions can be selected by rotating spherical operating element 10 about the y axis. To prevent operating errors, the rotational degree of freedom of spherical operating element 10 about the x axis of the underlying coordinate system is blocked during a roll operation within the described header via the spherical operating element. This is achieved in that second plunger 35 is pressed with high force in the positive y direction against sphere 10. As a result, a high braking torque occurs between spherical operating element 10 and second plunger 35 with respect to a rotation about the x axis,

thereby virtually blocking sphere 10 from rotating about the x axis.

As can be seen from Figure 8A, an approximately tangentially shaped characteristic of torque 205 within a list point 201 to 204 is assigned to header 200 of the menu as a function of position 206 within the menu such that, in response to the marking being positioned at a list point, a low required torque is assigned that increases in absolute value to a first value 231 when the marking is moved in the direction of an adjacent list point 201 through 204. In the represented diagram, an initially increasing torque 205 results in response to the operating element being rotated about the y axis in the positive direction, i.e., the marking (shaded portion) being displaced from left to right, being displaced from the instantaneous list point. If the boundary to the adjacent list point is crossed, a negative, i.e., corotating, torque results, so that the sphere automatically continues to rotate until the thus-moved marking is on the next list point, point 203 in this instance. Accordingly, a braking torque that increases in absolute value results in response to a reverse rotational direction from right to left until the boundary to next point 201 is crossed after which the direction of the acting torque reverses, thereby having a corotational effect on the sphere. The negative sign of the torque characteristic in response to motion in the negative rotational direction about the y axis results from the negative direction of the vectorially plotted (i.e., not using the absolute value) torque acting on the sphere.

Moreover, at the beginning and end of the menu, i.e., header 200 in this instance, within first and last list points 201 and 204, respectively, a further increase in absolute value of the torque needed to rotate the spherical operating element to a second value 232, which is greater than first value 231, is provided so that the user receives additional information

regarding the fact that, when moving sphere 10, the beginning or end of menu 200 is approaching.

If one of the parameters or functions 201 through 204 to be adjusted is selected by rotating the spherical operating element about its y axis, the selected parameter of selected function 201, 202, 203, or 204 is able to be adjusted by rotating spherical operating element 10 about its x axis. Thus, a desired program is able to be selected under point 201 from a list of the radio programs 210, 211, ..., 220 receivable at the receiver location by scrolling in the list by rotating spherical operating element 10 about its x axis.

As Figure 8B shows, a variable torque characteristic as described in connection with Figure 8A is provided from one list entry to another for rotating the sphere, so that the sphere stops when the marking controlled by sphere 10 and designated by the shaded portion in the figure is located at a list entry. To move the marking via the spherical operating element, a torque increased in absolute value is necessary.

It is further provided that the necessary torque significantly increases in absolute value at the beginning and end of program list 210 to 220, so that the user receives information about the fact that he/she is reaching the beginning or end of the list. If the user overcomes the increased torque at the beginning of the list and continues to rotate spherical operating element 10 in the negative direction, the marking stops again on point 201 of the header.

Analogously, under selected point 203, for example, the sound of the car radio is able to be shifted within a value range 230, 231, ..., 250 from a treble-loaded to a bass-loaded sound, value 240 representing, for example, a neutral sound. While a selected parameter is being adjusted, it is in turn provided that the spherical operating element is prevented from rotating about the y axis by blocking this rotational

degree of freedom. Thus, while adjusting the reproduction volume, for example, an unintentional rotation of the sphere about the y axis is prevented from changing the set station or also the volume instead of the sound since preventing the spherical operating element 10 from rotating about its y axis virtually eliminates an unintentional change to one of the other parameters 201, 202, or 204.

With respect to sound adjustment 203 to be performed using the indicated sound balance, the force acting on first plunger 30 and, thus, the braking torque acting on sphere 10 are controlled such that, in the case of a neutral sound setting about value 240, the torque needed to rotate sphere 10 is minimal, so that sphere 10 stops in the case of a neutral sound setting while it increases in response to an adjustment of the sound in the direction of a reproduction having more treble, i.e., smaller values, as well as in the direction of a reproduction having more bass, i.e., greater values. Finally, the torque needed to rotate sphere 10 increases abruptly near the end and the beginning of the sound balance, so that also in this instance the user receives information regarding the end of the adjustment region.

While the stop function with respect to the torque necessary to rotate the sphere is also possible in connection with the plungers of the first exemplary embodiment, the sphere is only able to jump from one deflection to the next stop position in connection with the actuators of the second embodiment.

In the first as well as the second example embodiment, it is provided that for controlling the torque needed to rotate the spherical operating element, the actual position of the sphere or the position of a pointer assigned thereto or of a marking within a menu is determined, and this actual position is assigned a certain torque. For this purpose, torque values for every position are stored in a table that are read out as a function of the actual position of the sphere or of the

pointer and are used to control plunger 30, 35 of the first exemplary embodiment or actuators 60, 61 and 65, 66 of the second exemplary embodiment and, thus, to impress the braking moment or, in the case of the jumping of the sphere, to impress the active torque on spherical operating element 10.

A further application case for the operating element of the present invention is, for example, as means for inputting a destination for a vehicle navigational device. A map having, for example, a plurality of cities as possible destinations is shown on the display unit of the navigational device for entering a destination. To mark a destination on a map, a cursor is able to be moved against the background of the map representation in the x and y direction using the operating element. In this context, it is provided, for example, that the torque acting on the spherical operating element is controlled such that the sphere is able to be rotated in both dimensions with constant torque while the operating element stops on cities on the map as potential destinations. Thus, the increment predefined by the controllable torque or the stopping of the operating element does not have to be constant, but are also able to be flexibly controlled in the case of the cities represented on the map, for example, as a function of their location and distance.